Clinical Update

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Traumatic Dental Injuries – Fractures and Luxations

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Introduction

Traumatic dental injuries (TDIs) occur at a high frequency. With 25% of all school age children experiencing a dental injury, and 33% of all adults, it is incumbent that dentists know how to manage such injuries (1). The purpose of this *Clinical Update* is to outline the treatment objectives and recent revisions in managing fractures and luxations from the *International Association of Dental Traumatology (IADT) guidelines for the management of traumatic dental injuries: 1. Fractures and luxations of permanent teeth* (2). The IADT guidelines classify TDIs into three categories: **fractures of teeth and alveolar bone, luxation injuries, and avulsions**. This Clinical Update will focus only on fracture and luxation injuries. Avulsions will be addressed in a later Clinical Update.

Clinical Examination

A thorough initial examination is paramount in making an accurate diagnosis and treatment plan. This should include an interview with the patient or guardian to collect the details of the accident and a description of the patient's chief complaint. A medical history and health assessment should follow to identify potential bodily injuries that would preclude dental treatment and necessitate referral to a medical provider. After ruling out any non-odontogenic injuries, an extra and intraoral examination is indicated. The patient's facial skeleton should be palpated to identify potential facial fractures. To examine the soft tissue, gently wash any lacerations, contusions, or tissue abrasions to better visualize the field and gently palpate the tissues for debris or impacted tooth fragments. Take care to inspect the periodontium for bleeding from the sulcus; this could be indicative of tooth displacement, crown-root fracture, or alveolar fracture (3).

Radiographic Examination

Radiographs are an essential part of the examination. Alveolar fractures, crown or root fractures, tooth displacement, and root apex maturation can all be discerned by use of proper, diagnostic radiographs. The 2012 International Association of Dental Traumatology (IADT) recommends several projections and angulations, but maintains the clinician should ultimately decide which radiographs to expose for each case. The following are advocated: 1) periapical radiograph with central beam directed 90° through tooth (or teeth) in question, 2) Occlusal view, 3) mesial or distal angulated radiograph through tooth in question (2). Although not currently used routinely, imaging modalities such as limited field of view cone-beam computerized tomography (CBCT) may be beneficial in acquiring additional information, such as fractures or displacement, where two-dimensional radiographs have limitations (4).

Splinting

Timely repositioning and splinting of displaced teeth are the most important elements in promoting healing. Teeth displaced due to root fractures or luxations should be repositioned and stabilized with a non-rigid splint for 4 weeks. Non-rigid splints are those that allow for physiologic movement of the tooth and include bonded monofilament wire, Kevlar, or fiberglass. Splint time will ultimately depend on the severity of the injury, but literature suggests no added benefit to splinting longer than 4 weeks. Furthermore, the type of injury has more effect on healing than the splinting type or duration (5, 6).

Antibiotics

There is little evidence that antibiotic use improves healing after a TDI. In fact, evidence concludes that the use of antibiotics has no effect on periodontal healing after tooth avulsion (7). The IADT's 2012 guidelines suggest that the use of antibiotics be left to the provider's discretion since TDI's are often associated with soft tissue injuries, which may require surgical intervention. Additionally, the patient's medical condition may dicate antibiotic coverage; therefore, the dentist must rely on their clinical judgment and take into account all relevant factors. If in doubt, consulting a specialist or medical provider may be necessary (2).

Sensibility Testing

Sensibility tests, such as thermal tests and electric pulp test (EPT), are meant to reveal the pulpal status of teeth. In a tooth that has recently sustained a TDI, pulp testing results cannot be considered a reliable indicator of the vitality of the pulp. However, pulp testing is imperative to perform so a baseline response can be established. Follow-up evaluations are crucial to track the pulpal status. Teeth that respond normally at the initial exam may prove to have negative responses to sensibility testing at subsequent appointments, and teeth exhibiting a negative response to sensibility testing may in turn display positive signs at a later date indicative of a healing pulp. Traumatic injuries are assumed to disrupt normal nerve transduction but may not disrupt blood supply. Sensibility testing only detects nerve function; so subsequent testing must be administered in order to gain a more accurate diagnosis of the pulp (8).

Immature versus Mature Permanent Teeth

The maturity of the tooth must be considered when developing a definitive treatment plan. Most TDIs occur in school-aged children whose immature pulps have tremendous capability for healing and regeneration. The literature supports the practice of vital pulp therapies, such as direct pulp cap and partial or full pulpotomy, in immature teeth secondary to TDIs, that ultimately facilitate complete root formation (9, 10). Moreover, immature teeth presenting with necrotic pulps have responded well to revascularization or regenerative procedures. These roots may result in further root development otherwise not obtained with a traditional pulpectomy or root canal therapy (11, 12). Mature teeth presenting with pulp necrosis are receptive to treatment with pulpectomy since the apex is fully formed and the dentinal walls are of substantial thickness (2).

Pulp Canal Obliteration

Pulp canal obliteration (PCO) is a replacement of the canal space with hard tissue and may be observed in teeth following a TDI. It is commonly seen in luxation injuries including root fractures (13). Generally, a higher frequency of PCO is observed in more severe injuries, although literature suggests that a relatively few number, 7-21%, of these teeth proceed to a necrotic state. Given the infrequent occurrence of pathosis associated with PCO, root canal treatment is not indicated unless the tooth becomes symptomatic or develops apical pathosis (14).

Treatment Guidelines for Fractures of Teeth and Alveolar Bone

Fractures of teeth and alveolar bone are sub-categorized into the following: **infractions, enamel fractures, enamel-dentin fracture, enamel-dentin-pulp, crown-root fracture without pulp exposure, and crown-root fracture with pulp exposure.**

Clinical findings for **infraction injuries** consist of an incomplete fracture of enamel without loss of tooth structure. No treatment or follow-up is required for these teeth.

An **enamel fracture** or **enamel-dentin fracture** consists of a complete fracture of enamel with loss of tooth structure with or without exposed dentin. These teeth are usually not tender to palpation or percussion and show normal pulp sensibility responses. Treatment involves bonding tooth

segment back in place or placing a glass ionomer or resin restoration over the exposed dentin. If the exposed dentin is less than 0.5 mm thick, a pink hue may be seen representing the pulp tissue. A calcium hydroxide or MTA base may be placed beneath the restoration to promote dentin generation (15, 16).

Teeth with **enamel-dentin-pulp fractures** present with many of the same signs as enamel-dentin fractured teeth but include the added complication of an exposed pulp. All attempts to preserve pulp vitality are recommended, especially in immature teeth. This can be accomplished through either pulp capping or partial or full pulpotomy. The tooth fragment can be bonded back to the tooth or another suitable dental material may be used as a temporary restoration.

If the fracture extends sub-gingivally or sub-crestal to bone, into the root, it is classified as a **crown-root fracture**, and additional considerations are warranted. If the pulp is not exposed, emergency treatment may include stabilization of the fractured tooth fragment until definitive treatment can be administered. Definitive treatment may include gingivectomy, ostectomy, or orthodontic extrusion in order to generate ample tooth structure for restoration. If the fracture is too large, extraction and implant placement may be indicated.

If the fracture extends into the root and the pulp is exposed, care should be taken to maintain vitality in immature teeth. Restorative options are very similar to crown-root fractures without pulpal exposures. Post and core restorations may be needed to facilitate retention of the restoration (2).

Treatment Guidelines for Luxation Injuries

The 2012 IADT guidelines classify luxation injuries as the following: **root fractures**, **alveolar fractures**, **concussion**, **subluxation**, and either **extrusive**, **lateral**, or **intrusive luxations**.

Root fractures exhibit intra-alveolar fractures of cementum, dentin, and pulp. Clinical findings may include percussion sensitivity, a displaced coronal segment, sulcular bleeding, and potential negative responses to initial sensibility testing. Multiple horizontal and vertical angulations are highly encouraged when taking radiographs due to the difficulty in visualizing fractures radiographically. Alternatively, a limited field of view CBCT can be obtained to supply the clinician with a three-dimensional representation of the area that may facilitate better appreciation of the extent of the injury. Treatment should consist of early reduction and splint stabilization of the coronal segment if displaced (2, 17). Pulpal status should be monitored for at least one year. If the pulp becomes necrotic, root canal treatment on the coronal segment only is indicated. Consultation with an endodontist is recommended if a lesion developes on the apical segment subsequent to root canal treatment of the coronal portion (18).

Intrusive luxation injuries are the most damaging of all TDIs. An extremely high rate of necrosis has been documented with these injuries due to the shearing effect the axial displacement of the tooth has on the apical pulpal and periodontal tissue. The stage of root development has the greatest impact on whether the tooth will become necrotic. Clinically, these teeth present with a tooth displaced axially into the alveolar bone, are immobile, and typically produce a metallic sound upon percussion. These teeth should be allowed 2-4 weeks to re-erupt; however, if no eruption occurrs, the tooth should be orthodontically or surgically repositioned and splinted. If the tooth is intruded more than 7 millimeters, immediate repositioning should be performed (19).

For all other luxation injuries (**extrusive and lateral)**, treatment consists of manually repositioning the tooth and splinting for 2-4 weeks. For **alveolar fractures,** a segment of several teeth may be mobile and repositioning of the entire segment is indicated. Gingival lacerations should be properly cleansed and sutured if present. A rigorous follow-up schedule of 2, 4, and 6-8 weeks, 6 months, 1 year, and yearly for 5 years is indicated to monitor pulpal status and check for signs of resorption or periodontal deterioration (2).

Conclusion

Treatment of TDIs requires an astute evaluation of the type of injury and a tailored treatment plan to maximize the prognosis for each case. An interactive, comprehensive web-based representation of TDI guidelines can be accessed on the web at http://www.dentaltraumaguide.org (Illustrations used in the following tables are provided courtesy of www.dentaltraumaguide.org and Copenhagen University Hospital). Guidelines for TDIs can also be obtained from the American Association of Endodontists, 2004 (20).

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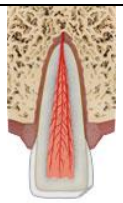
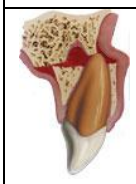
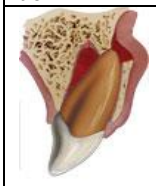
IADT Guidelines for Fractures of Teeth and Alveolar Bone (2)

Illustrations are provided courtesy of www.dentaltraumaguide.org and Copenhagen University Hospital

Injury	Clinical Findings	Radiographic Findings	Treatment	Follow-up	Favorable Outcome	Unfavorable Outcome
 Infraction	• Crack in the enamel • Non-tender	• No radiographic abnormalities	• Etch and seal with resin if marked, otherwise no treatment	No follow-up necessary	• Asymptomatic • Positive response to pulp testing • Continuing root development in immature teeth	• Symptomatic • Negative response to pulp testing • Apical Periodontitis • No continuing root development in immature teeth
 Enamel Fracture	• Complete fracture of enamel with no exposed dentin • Pulp testing normal	• Loss of enamel is visible	• Bond tooth fragment back in place or recontour with composite	6-8 weeks 1 year	• Asymptomatic • Positive response to pulp testing • Continuing root development in immature teeth	• Symptomatic • Negative response to pulp testing • Apical Periodontitis • No continuing root development in immature teeth
 Enamel-Dentin Fracture	• Fracture confined to enamel and dentin • No mobility • Positive pulp tests	• Loss of enamel and dentin visible	• Bond tooth fragment in place or recontour with composite • If within 0.5mm of pulp, place $Ca(OH)_2$ or MTA base	6-8 weeks 1 year	• Asymptomatic • Positive response to pulp testing • Continuing root development in immature teeth	• Symptomatic • Negative response to pulp testing • Apical Periodon titis • No continuing root development in immature teeth
 Enamel-Dentin-Pulp Fracture	• Fracture with pulp exposure • No mobility • Exposed pulp sensi tive to testing	• Loss of tooth structure visible	• Pulp capping or partial pulpotomy with$Ca(OH)_2$ and glass ionomer in immature teeth • In mature teeth, RCT usually indicated	6-8 weeks 1year	• Asymptomatic • Positive response to pulp testing • Continuing root development in immature teeth	• Symptomatic • Negative response to pulp testing • Apical Periodontitis • No continuing root development in immature teeth
 Crown-Root Fracture without Pulp Exposure	• Fracture extending below gingival margin involving enamel, dentin, and cementum but not pulp • Percussion sensitive • Positive pulp response for apical segment	• Fracture line possible to see but usually not identified	• Stabilization of the loose segment to adjacent teeth can be used as emergency treatment • Definitive treatment involves removal of coronal segment and restoration of apical fragment via: 1) crown lengthening (only if sub-gingival fracture is located on the palatal side) or 2) orthodontic or surgical repositioning • RCT may be indicated to restore with post/core restoration • Consider implant therapy in fractures with severe apical extent	6-8 weeks 1 year	• Asymptomatic • Positive response to pulp testing • Continuing root development in immature teeth	• Symptomatic • Negative response to pulp testing • Apical Periodon titis • No continuing root development in immature teeth
 Crown-Root Fracture with Pulp Exposure	• Fracture extending below gingival margin involving enamel, dentin, cementum, and exposing the pulp • Percussion sensitive	• Fracture line possible to see but usually not identified	• Stabilization of the loose segment to adjacent teeth can be used as emergency treatment • In immature teeth, tooth vitality should be maintained with partial pulpotomy using a CaOH base • Definitive treatment involves RCT and post/core restoration preceded by removal of coronal segment and either 1) crown lengthening (if sub-gingival fracture is located on the palatal side) or 2) orthodontic or surgical repositioning • Consider implant therapy in fractures with severe apical extent	6-8 weeks 1 year	• Asymptomatic • Positive response to pulp testing • Continuing root development in immature teeth	• Symptomatic • Negative response to pulp testing • Apical Periodontitis • No continuing root development in immature teeth

IADT Guidelines for Luxation Injuries (2)

Illustrations are provided courtesy of www.dentaltraumaguide.org and Copenhagen University Hospital

Injury	Clinical Findings	Radiographic Findings	Treatment	Follow-Up	Favorable Outcome	Unfavorable Outcome
 Root Fracture	• Coronal segment may be mobile • Tenderness to percussion • Bleeding from the sulcus may be noted • Pulp tests may be negative initially (follow-up necessary)	• A fracture in the horizontal plane can be detected if the x-rays are directed through the plane of the fracture	• Reposition the coronal segment if displaced and check position radiographically • Stabilize with flexible splint for 4 weeks (up to 4 months if fracture is in cervical area) • Monitor healing for 1 year and if necrosis occurs, RCT of coronal segment to level of fracture is indicated	4 weeks 6-8 weeks 4 months 6 months 1 year 5 years	• Positive response to pulp testing (false negative possible up to 3 months) • Signs of repair between fractured segments	• Symptomatic, Negative response to pulp testing, extrusion of coronal segment • Radiographic or clinical signs of lesion around the fracture line
 Alveolar Fracture	• Fracture that involves alveolar bone • Mobility of segment of several teeth is common • Occlusal disharmony • Pulp testing unpredictable	• Fracture lines can be seen anywhere from marginal bone to root apex • Panoramic images are helpful in determining fracture location	• Reposition displaced segment(s) • Flexible splint for 4 weeks • Suture gingival laceration if present	4 weeks 6-8 weeks 4 months 6 months 1 year 5 years	• Positive response to pulp testing (false negative possible up to 3 months) • No signs of apical periodontitis	• Symptomatic, negative response to pulp testing • Signs of apical periodontitis or external inflammatory root resorption
 Concussion	• Tooth is tender to touch or percussion • No mobility • Pulp testing likely positive	• No radiographic abnormalities	• No treatment necessary • Monitor pulpal status for at least 1 year	4 weeks 6-8 weeks 1 year	• Asymptomatic • Positive response to pulp testing (false negative possible up to 3 months) • Continuing root development in immature teeth	• Symptomatic, negative response to pulp testing • No continuing root development in immature teeth • Apical periodontitis
 Subluxation	• Tooth is tender to touch or percussion • Increased mobility but not displaced • Bleeding from gingival crevice may be seen • Pulp testing may be negative	• No radiographic abnormalities	• No treatment necessary • Flexible splint for up to 2 weeks may be used to stabilize tooth for patient comfort	2 weeks 4 weeks 6-8 weeks 6 months 1 year	• Asymptomatic • Positive response to pulp testing (false negative possible up to 3 months) • Continuing root development in immature teeth	• Symptomatic, negative response to pulp testing • No continuing root development in immature teeth • Apical periodontitis • External inflammatory resorption
 Extrusive Luxation	• Tooth appears elongated • Excessively mobile • Pulp tests likely negative	• Increased periodontal ligament space apically	• Reposition tooth by gently re-inserting it back into the socket • 2 week stabilization with flexible splint • RCT in mature teeth or if signs and symptoms of immature teeth indicate necrosis	2 weeks 4 weeks 6-8 weeks 6 months 1 year Annually for 5 years	• Asymptomatic • Radiographic/clinical signs of healed periodontium • Positive response to pulp testing • Marginal bone height corresponds to pre-trauma level	• Apical periodontitis • Negative response to pulp testing • If breakdown of marginal bone, splint for additional 3-4 weeks • External inflammatory root resorption
 Lateral Luxation	• Tooth displaced horizontally • Immobile • Percussion yields high, metallic (ankylotic) sound • Alveolar process fracture present • Pulp tests likely negative	• Widened periodontal ligament space can be seen on eccentric views	• Reposition tooth digitally or with forceps to disengage from bony lock • 4 week stabilization with flexible splint • Monitor pulpal condition; if necrotic, RCT indicated to prevent resorption	2 weeks 4 weeks 6-8 weeks 6 months 1 year Annually for 5 years	• Asymptomatic • Radiographic/clinical signs of healed periodontium • Positive response to pulp testing • Marginal bone height corresponds to pre-trauma level	• Apical periodontitis • Negative response to pulp testing • If breakdown of marginal bone, splint for additional 3-4 weeks • External inflammatory root resorption
 Intrusive Luxation	• Tooth displaced axially into alveolar bone, immobile • Percussion yields high, metallic sound • Alveolar process fracture present • Pulp tests likely negative	• Periodontal ligament space absent • CEJ located more apically (may be as far apical as the marginal bone level) than in adjacent teeth	• In immature teeth, allow tooth to erupt unassisted. If no movement after a few weeks, reposition orthodontically • The same guidelines apply for mature teeth but RCT should be initiated 2-3 weeks after repositioning ($Ca(OH)_2$ recommended as temporary intracanal filling)	2 weeks 4 weeks 6-8 weeks 6 months 1 year Annually for 5 years	• Tooth in place or erupting • No signs of apical periotdontitis or resorption • Continuing root development in immature teeth	• Tooth locked in place/ankylotic sound to percussion • Apical periodontitis • External inflammatory resorption or replacement resorption